REMARKS/ARGUMENTS

Claims 1, 4-11 and 20 are pending in this application. Claims 2, 3 and 12 have previously been canceled. Claims 13-19 have been withdrawn.

The claims, and the invention defined by them, are directed to effectively and efficiently operating fuel cells. As is well known, many fuel cells, such as molten carbonate fuel cells, for example, generate a relatively hot anode exhaust gas that typically has a temperature in the range between about 1200°-1300°F. The anode exhaust gas includes combustible materials. The heat of the anode exhaust gas, together with the energy available from the combustible materials of the gas, are utilized, rather than discharged, to enhance the efficiency of the fuel cell by directing the gas through a catalytic oxidizer to heat it for subsequent recirculation to the cathode side of the fuel cell in a closed loop from the anode side to the cathode side of the fuel cell, although the cathode exhaust is then discharged.

When operating fuel cells, particularly large, stationary fuel cells used in power plants, for example, the temperature of the anode exhaust gas emitted by the fuel cell at times has a high concentration of combustible components that is above the auto-ignition temperature (in the range between about 800°-1200°F). This can lead to a spontaneous ignition of the anode exhaust gas, particularly when mixed with added air for oxidizing combustible materials in the anode exhaust gas. This problem is explained in paragraph [0005] of the present application as follows:

> ... portions of the anode gas form flammable and not flammable pockets of micro mixtures. The temperature of such pockets of flammable mixture can rise above the auto-ignition temperature of the combustible components, which can lead to instantaneous micro explosions creating rapid pressure pulsations, and/or combustion instabilities, all of which are detrimental to the equipment, including the fuel cell. Controlling the flammability conditions during the mixing process is complicated by the fact that changes in the composition and flow of the anode gas can be abrupt, for example, when there are sudden changes in the power demand placed on the fuel cell.

Especially in large scale, industrial fuel cell plants, the combustion of the anode exhaust gas is difficult to control during upset conditions when its composition and temperature

vary widely. This can lead to substantial and destructive operating instabilities and, ultimately, explosions.

The present invention reduces the temperature of the anode exhaust gas exiting the fuel cell "so that the peak temperature in the mixing zone is below the auto-ignition temperature of the fuel components [in the anode exhaust gas] while maintaining the overall bulk mixed temperature sufficient to initiate the catalytic oxidation" of the anode exhaust gas. [0009] In other words, the present invention as defined by the claims eliminates the conditions that can lead to spontaneous ignitions in the anode exhaust gas when mixed with air or, to put it differently, it eliminates conditions that can lead to the rapid, non-catalytic oxidation of the anode exhaust gas and the formation of instabilities, explosions, flames and the like. To attain this, the mixture of anode exhaust gas and air must not be flammable anywhere in local pockets under the conditions (e.g. temperature, composition and pressure) encountered in the system, so that, instead of forming a flame, the combustible materials in the anode exhaust gas oxidize gradually, for example, on the catalyzed surfaces of the oxidizer.

It is central to the present invention that the air which is to be admixed with the hot anode gas be used to cool the anode exhaust gas, thereby simultaneously heating the air. Thereafter the cooled anode exhaust gas and the heated air are mixed before the resulting mixture is oxidized and then flowed to the cathode intake of the fuel cell.

Thus, by cooling the anode exhaust gas (with air) before mixing the two, the formation of local, auto-ignitable pockets in the mixture and resulting instabilities, fuel ignitions and the like are prevented. The anode exhaust gas can therefore be directed to the catalytic reactor or oxidizer 28, where the combustible components of the anode exhaust gas are catalytically oxidized.

As a result, the approach of the present invention defined by the independent claims would not be suitable and could not be employed in a system where auto-ignition is desired or poses no problems.

The invention summarized above is defined by the independent claims as follows.

Independent claim 1 recites amongst others "adding ambient air to the anode gas to form an oxidizable anode gas mixture, transferring heat from the anode gas to the air before the air is added to the anode gas to thereby lower a temperature of the anode gas, ... catalytically oxidizing the mixture ... and flowing the effluent to the fuel cell"

Independent claim 9 requires in relevant parts "transferring heat from the anode gas to the air flow in the first and second flow paths to thereby decrease a temperature of the anode gas and form a cooled anode gas, thereafter mixing the cooled anode gas and the air flow downstream of the flow paths to form a mixture, directing the mixture through a catalytic oxidizer ... [and] flowing an effluent from the catalytic oxidizer to the fuel cell ...."

Likewise, independent claim 20 recites "adding air to the anode gas in an amount at least sufficient for oxidation of the combustible components to form an oxidizable anode gas mixture, ... exchanging heat between the air and the anode gas prior to forming the mixture to thereby lower local peak temperatures developing during forming the mixture, catalytically oxidizing the mixture to form an effluent, ... and flowing the effluent to the fuel cell".

In the claims, as well as throughout the entire application, "air" does not mean and does not include air mixed with another gas, but outside or ambient air. This is the unequivocal meaning of the word "air" as used in the specification. See, for example, paragraph [0023], which refers to ambient air, and Fig. 1, which shows air source 16 on the exterior of and entirely separate from the remainder of the system except for the flow connection (such as a tube) from the air source to the air conduit 18, as is described in paragraph [0018]).

In Woods, the principal reference over which the claims were rejected, ambient inlet air 112 flows via passage 114 to reformer 116 where it is mixed with inlet fuel 166 to generate a reformer product gas which flows as anode gas into passage 168 via channel 190 to the anode manifold of the fuel cell. [0023], [0024], [0025] and [0026]

Some inlet air 112 is diverted via orifice 128 to the cathode manifold of fuel cell 118. [0026]

Anode exhaust gas exiting fuel cell 118 flows via exit passage 134 into combustor 120 after undergoing some temperature quenching by virtue of contact with the flexible barrier

wall 126, which is in thermal contact with the relatively cooler inlet air 112. [0027] Inlet air 112 continues its flow in a downward direction (as seen in Figs. 1A and 1B) into reformer 116 as described above. The temperature of the anode exhaust gas is approximately 1500°F (which is above the auto-ignition temperature of 800°-1200°F of the gas). In the combustor, fuel in the anode exhaust gas received from the anode side of the fuel cell is ignited to liberate heat which is used by a heat transfer coil 142. The gases in the combustor are then discharged as exhaust gas 144 through exhaust duct 141. **[0027], [0042]**

In an alternative embodiment which seeks to generate additional heat in the combustor, Woods feeds additional fuel via conduit 136 and mixes it with the anode exhaust gas flowing through exit passage 134. The additional air needed to oxidize the additional fuel is fed via conduit 138 directly into combustor 120. **[0044]**

There is no attempt by Woods to prevent auto-ignition and the formation of flames downstream of the fuel cell and/or in the combustor 120 of Woods. To the contrary, Woods catalyzes surface element 14 through which the anode exhaust gas enters the combustor ([0042]) "to enhance spontaneous ignition or the combustion chamber 120 can be equipped with a spark ignition source (not shown)". **[0032]** (emphasis added) In Woods, the exhaust from the combustor is discharged to the outside and there is no conduit through which the exhaust from the combustor could flow back to the fuel cell. Pressure pulsations, ignitions, flames and the like caused by Woods' spontaneous ignition of the anode exhaust gas in the combustor therefore do not affect the operation of the fuel cell.

Woods makes no attempt to transfer heat from the anode exhaust gas to the air before the two are mixed and prior to oxidizing the fuel remaining in the anode exhaust gas in combustor 120. There is some cooling of the anode gas by air 112 flowing downwardly along conduit 114 to reformer 116 and some corresponding heating of that air. However, the so-cooled anode exhaust gas and so-heated air are not mixed thereafter.

A portion of the heated air in conduit 114 flows first to the fuel cell cathodes where other reactions take place so that the air becomes cathode gas (called by Woods "depleted air") that may exit the system altogether, when conduit 129 connected to the outside of the housing 110 (Woods **[0070]**), or is added to air 138 prior to entering the combustor 120. **[0044]**

The remaining portion of the heated air flows to the reformer 116 to generate the fresh, fuel-rich anode gas that is fed to the anode side of the fuel cell. Anode exhaust gas that was subjected to some cooling by air 112 flowing in conduit 114 is fed to combustor 120 and then discharged to the outside.

There is also no attempt by Woods to prevent auto-ignition by transferring heat from the anode exhaust gas to the air with which the anode gas is subsequently mixed to lower the temperature of the mixture to below the auto-ignition temperature. To the contrary, as was discussed above, Woods involves a conventional combustion process in which the anode exhaust gas/air mixture is ignited as soon as the mixture is formed in combustor 120.

As a result, Woods' system is incapable of preventing auto-ignition of the anode exhaust gas when mixed with air, as is required by the present invention, while the system of the present invention prevents the auto-igniting of the anode exhaust gas/air mixture because the temperature of the mixture is too low for that. The present invention catalytically oxidizes the fuel in the anode exhaust gas to assure a gradual, stable, non-explosive catalytic oxidation of the anode gas in catalytic oxidizer 28.

Thus, Woods does not disclose or in any form suggest:

- adding ambient air to the anode exhaust gas to form an oxidizable anode gas mixture, transferring heat from the anode exhaust gas to the air before the air is added to the anode exhaust gas to thereby lower a temperature of the anode exhaust gas, and catalytically oxidizing the mixture to form an effluent that is flowed back to the fuel cell as required by claim 1
- in a heat exchanger having first and second flow paths separated by a heat exchange member, directing an ambient air flow through the second flow path, transferring heat from the anode exhaust gas to the air flow in the respective flow paths to form a cooled anode exhaust gas, thereafter mixing the cooled anode exhaust gas and the air flow downstream of the flow paths to form a mixture, directing the mixture through a catalytic oxidizer, and then flowing it to the fuel cell as required by independent claim 9

- adding air to the anode exhaust gas, exchanging heat between the air and the anode exhaust gas prior to forming the mixture to thereby lower local peak temperatures, catalytically oxidizing the mixture to form an effluent, and directing the effluent back to the fuel cell as is required by independent claim 20.

Indeed, Woods never cools any anode exhaust gas with air with which the anode exhaust gas is subsequently mixed. The air that cools the anode exhaust gas of Woods is not combined with the anode exhaust gas, but flows to the reformer, or to the cathode manifold of the fuel cell, as is described, for example, in Woods [0026] and further discussed below. The supplemental air fed to combustor 120 via air inlet 138 neither cools the anode exhaust gas, nor is the anode exhaust gas and the air 138 mixed to result in a mixture that is flowed to the catalytic oxidizer or combustor 120. Whatever heat might be transferred from the anode exhaust gas to air 138 in combustor 120 is generated by mixing the two directly, and not via heat transfer prior to such mixing. Moreover, after ignition the effluent from the combustor is not returned to the fuel cell, but discharged to the outside.

Haltiner, the secondary reference which was combined with Woods to render the claims obvious, was relied upon only as disclosing the step of flowing the effluent from a catalytic oxidizer to the fuel cell. Haltiner contains no other disclosure that was relied upon in the rejection of the claims and does not disclose or in any form suggest what is missing from Woods relative to the independent claims as was discussed above.

Further, there is nothing in the experience and background of a person of ordinary skill in the art, or in the applied references, that would suggest to such person the above-discussed limitations of the independent claims or, conversely, who could come up with the above-discussed claim limitations based upon a perusal of Woods and Haltiner in light of the person's background and experience.

In this context, applicant notes that the obviousness rejection of the claims interprets Woods as disclosing that transferring heat "comprises forming first and second flow paths '134' & '114' for the anode exhaust gas and the air flow and separating the flow paths by a flexible heat transfer barrier wall '126' to transfer heat between the anode exhaust gas and the air

flow from the cooled anode exhaust gas", apparently referring to independent claim 9 which uses similar language. Claim 9 additionally requires thereafter (i.e. after heat has been transferred from the anode gas to the air flow) "mixing the cooled anode gas and the air flow downstream of the flow paths to form a mixture ...."

The other part of the air flow 112 through conduit 114 flows downwardly (as seen in Figs. 1A and 1B) to reformer 116 where it is used to generate the fuel-rich anode gas that is supplied to the anode side of the fuel cell. Air flowing through conduit 114 to reformer 116 is not mixed with anode exhaust gas. Passage 134 through which the anode exhaust gas flows to combustor 120 is separated by a large section of compression plate 130 as is shown in Fig. 1B so that that passage and the flow of air 114 are not in a heat exchange relationship.

Part of inlet air 112 flowing through conduit 114 is "diverted at orifice 128 to the fuel cell 118, [and] enters the cathode manifold of the fuel cell." (Woods [0026]). This air becomes part of the cathode gas and is not mixed with the anode gas or subsequently catalytically oxidized as required by the independent claims of the present application.

Thus, as demonstrated in the preceding paragraphs, air 138 that enters combustor 120 is not cooled in Woods by anode exhaust gas and, conversely, anode exhaust gas does not heat air 138. The two are mixed in combustor 120 and immediately ignited without any previous heat transfer between them to lower the temperature of the anode gas to below its auto-ignition temperature.

Finally, air 114 which flows to reformer 116 may transfer some heat via barrier wall 126 to anode exhaust gas from the fuel cell. This air is fed to reformer 116 where it is combined with fuel to provide the fuel-rich anode gas for the fuel cell. Air fed to the reformer becomes part of the fuel-air mixture that is reacted in the fuel cell and is not mixed with the anode exhaust gas, as is required by the independent claims.

Accordingly, under no conceivable reading/interpretation of Woods, does Woods ever mix ambient air with anode exhaust gas after a heat transfer from the hot anode exhaust gas to the air as required by the independent claims.

In Woods, there is no heat transfer from hot anode exhaust gas to the air with which combustible materials in the anode exhaust gas are oxidized. In Woods, the hot anode exhaust gas is mixed with air, without any preceding heat transfer between the two, and immediately ignited. In contrast thereto, all independent claims require oxidization of the mixture after the heat transfer between the constituents of the mixture.

The fact that there is some heat transfer between air flow 114 of Woods and the fuel cell in no way affects the allowability of the independent claims because that heat transfer is between gases in the fuel cell and air that is not mixed with the anode exhaust gas after such heat transfer.

Applicant also disagrees with the comment under "Response to Arguments" that paragraph [0027] of Woods discloses quenching the exhaust gas from the fuel cell by transferring heat from the anode gas to the inlet air 112. Paragraph [0027] does comment that the anode exhaust gas temperature might be lowered due to such quenching, but the anode exhaust gas is not then mixed with the inlet air 112 that was used to cool the gas. As mentioned above, that air either flows to reformer 116 for generating fresh, fuel-rich anode gas or through aperture 128 to the cathode manifold of the fuel cell.

Applicant further disagrees with the additional argument on page 5 of the Office Action that since this heat transfer from the anode gas to the inlet air 112 is performed before the air from the cathode exhaust gas is mixed with the anode exhaust gas in the combustor, "the cathode exhaust gas that is added to the anode exhaust gas in the combustor is construed as the air that is added to the anode gas to form an oxidizable anode gas mixture". The cathode gas plays no role in the present invention other than the observation that the effluent from the oxidizer 28 of the present invention is fed to the cathode side of the fuel cell. More importantly, this argument is incorrect. The "air" recited in the independent claims is outside or ambient air, as was discussed above. It is not air that is mixed with other gases and becomes the cathode gas.

There is also no justification in either Woods, Haltiner or the present application to equate any air that may be contained in the cathode exhaust gas to the outside or ambient air with which the anode exhaust gas is mixed downstream of the heat exchanger of the present invention. There is no basis anywhere in the record of this application that air contained in the

cathode exhaust gas of Woods is the same as or can be treated as an equivalent to the air that is mixed with the cooled anode exhaust gas in the context of the present invention. In addition, construing the cathode gas as constituting the "air" of the independent claims would render the system inoperative because the cathode exhaust gas is hot and has a temperature comparable to that of the anode exhaust gas because both are effluents from the same fuel cell so that little or no heat transfer between the two could occur. Thus, equating air to the cathode exhaust gas amounts to speculation that is not supported by Woods.

Moreover, the independent claims of the present invention affirmatively require heat transfer from the anode exhaust gas to the air and subsequent mixing of the cooled anode exhaust gas and the correspondingly heated air before they are introduced into the catalytic oxidizer for the purpose of lowering the temperature of the mixture to below its auto-ignition temperature. This is what the pending independent claims require. It is inappropriate to disregard the claimed requirement that heat is transferred from the anode exhaust gas to ambient air and in effect reword the claims as if they required that heat from the anode gas is transferred to the cathode exhaust gas.

Independent claims 1, 9 and 20 are therefore not obvious over Woods, taken alone or in combination with Haltiner.

In view of the foregoing, applicant submits that independent claims 1, 9 and 20, and claims 4-11 which depend from them, are allowable, and a formal notification to that effect at an early date is requested.

If the Examiner believes a telephone conference would expedite prosecution of this application, please telephone the undersigned at (415) 576-0200.

Respectfully submitted,

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